

## Four-Fold Improvement of 3C-SiC PN Junction Diode Blocking Voltage Obtained Through Improved CVD Epitaxy on Low-Tilt-Angle 6H-SiC Wafers

Philip G. Neudeck, David J. Larkin, Jonathan E. Starr<sup>\*</sup>, J. Anthony Powell,  
Carl S. Salupo<sup>†</sup>, and Lawrence G. Matus

NASA Lewis Research Center, M. S. 77-1, 21000 Brookpark Rd, Cleveland, OH 44135 USA  
Phone: (216) 433-8902

<sup>\*</sup>Student Intern, Ohio Aerospace Institute, 2001 Aerospace Pkwy., Brook Park, OH 44142 USA

<sup>†</sup>Calspan Corporation, Middleburg Heights, OH 44130 USA

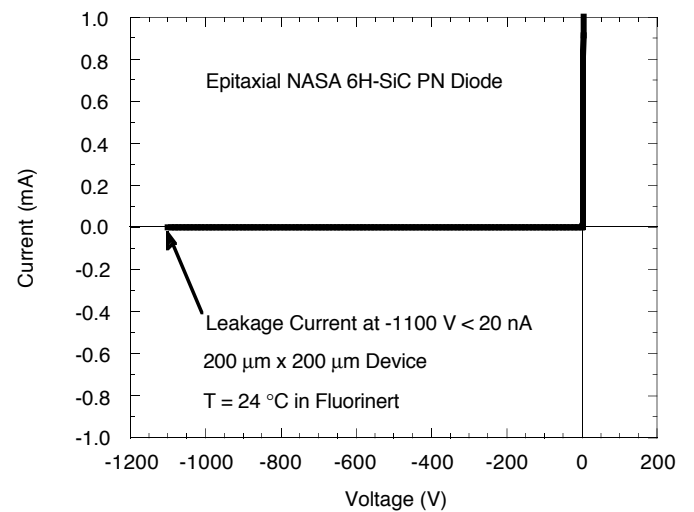
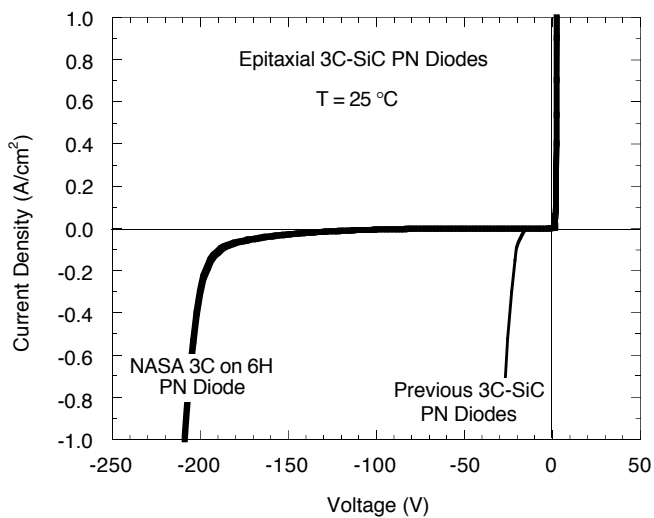
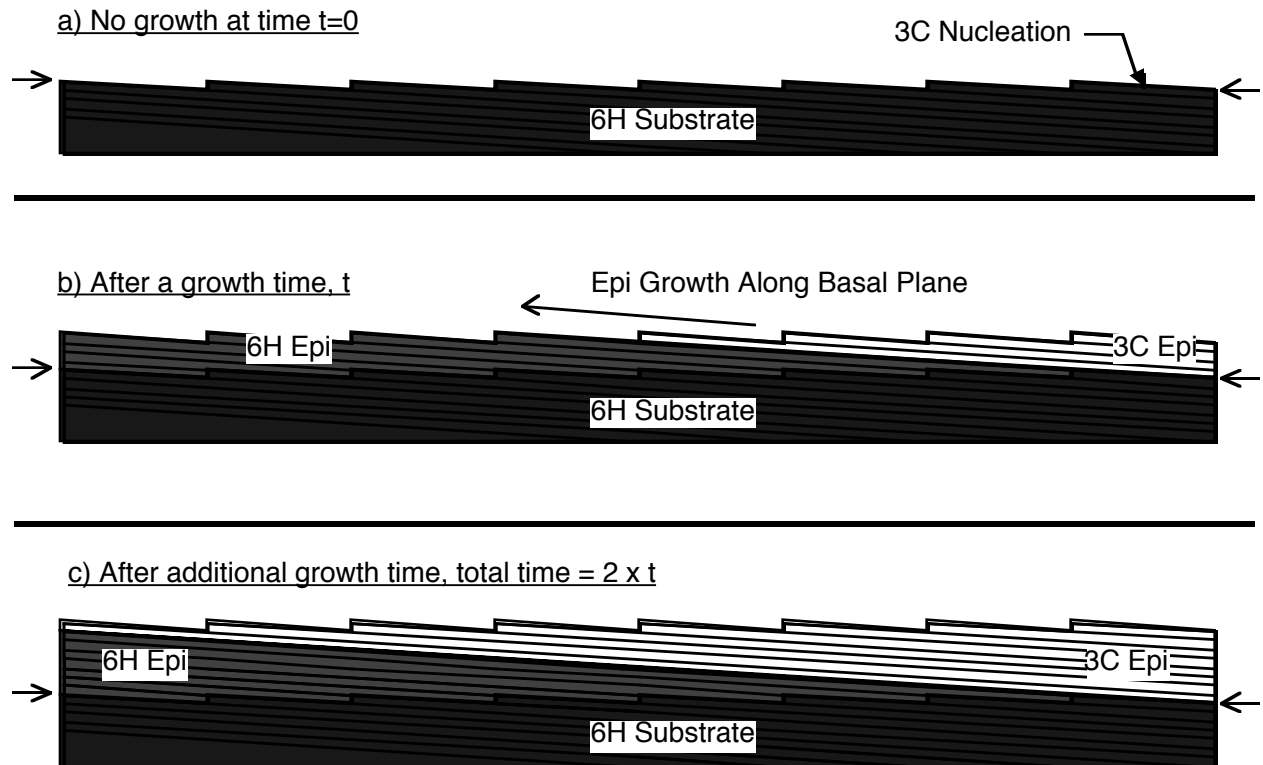
In recent years there has been increasing interest and research into single-crystal silicon carbide (SiC) as a semiconductor for use in high-temperature, high-power, and/or high-radiation operating conditions under which silicon and conventional III-V semiconductors cannot adequately function. Of the two most common SiC polytypes investigated to date (6H-SiC and 3C-SiC), the 6H polytype has clearly yielded far superior electrical device results. However, this is almost entirely due to the fact that growth techniques for producing substrates and epitaxial films in the 6H material are well-advanced compared to 3C-SiC crystal growth methods.

3C-SiC has some important material property advantages over 6H-SiC, such as higher low-field electron mobility, which could be exploited to produce superior devices and circuits for microwave power and other applications. Because no technique has been developed for obtaining semiconductor device quality 3C-SiC on suitably large substrates, these property advantages have not been realized in electrical devices or circuits. Given the lack of 3C substrates suitable for mass production, efforts have focused on heteroepitaxial growth of 3C-SiC layers on silicon and other potentially large-area, reproducible substrate materials. To date however, the crystallographic quality of the 3C-SiC resulting from these efforts has been poor, and this has been reflected in poor electrical characteristics of diodes and transistors fabricated in the resulting 3C-SiC material. Diode junctions at room temperature have been very leaky and incapable of rectification beyond a few 10's of volts reverse bias, and 3C-SiC transistors on substrates suitable for mass production have likewise been extremely limited in their capabilities.

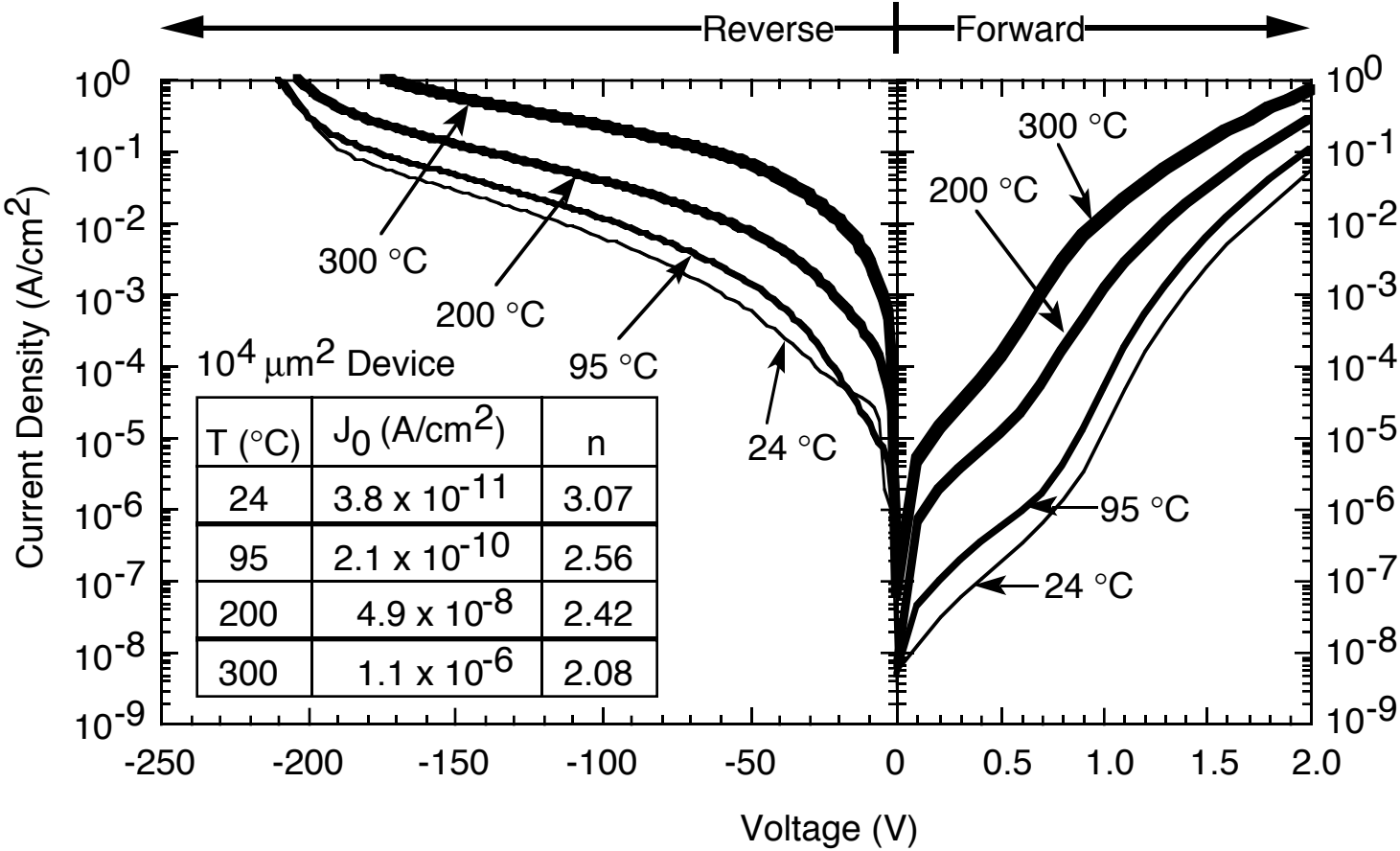
In this work we report on the growth, fabrication, and initial electrical characterization of greatly improved 3C-SiC pn junction diodes. **These diodes, which were grown on commercially available 6H-SiC wafers by an improved SiC chemical vapor deposition (CVD) process, demonstrate rectification to 200 V at room temperature. This represents a greater than 4-fold improvement in reported 3C-SiC diode blocking voltage. Under sufficient forward bias, the diodes emit a green-yellow light, which to the best of the authors' knowledge is the first report of a significantly bright CVD-grown 3C-SiC light emitting diode.** The reverse leakage currents and forward saturation current densities measured on these diodes also show significant improvement compared to previously reported CVD-grown 3C-SiC pn junction diodes. The vastly improved diode characteristics are directly attributable to improvements in the 3C-SiC CVD growth process which have increased crystal purity, eliminated double-positioning-boundary (DPB) defects, and greatly reduced stacking fault densities. **These results should lead to substantial advancements in the capabilities and performance of most single-crystal 3C-SiC electrical devices.** However, there is still room for improvement in the epitaxial material quality and electrical device characteristics, as some stacking faults are still present in the 3C-SiC epilayers and diodes.

Late news paper presented at 1992 IEEE International Electron Devices Meeting, San Francisco, CA  
IEDM Technical Digest pp. 1003-1005, 1992 © IEEE

# Model for lateral growth of a 3C-SiC film on a vicinal (0001) 6H-SiC substrate



Epitaxial NASA 3C-SiC PN Diode Current-Voltage Characteristics



Blue-violet 6H-SiC LED (left) and green-yellow 3C-SiC LED (right) epitaxially grown on the same 6H-SiC Substrate.

